CLAIMS

1. A memory device comprising:

a plurality of memory cells connected electrically in series; and

a plurality of switching elements connected in parallel with said memory cells in one-to-one correspondence;

wherein each of said memory cells is comprised of a magnetoresistive effect element having a plurality of magnetoresistive effect element portions;

wherein said magnetoresistive effect elements are laminated on one surface side of a substrate and disposed in a direction parallel to laminated surfaces of said magnetoresistive effect elements with respect to one another;

wherein said magnetoresistive effect element portions in each of said magnetoresistive effect elements are electrically connected in series so as to form an electric series connection body;

wherein opposite ends of said series connection body in each of said magnetoresistive effect elements are electrically connected to a sensing current supply portion so that a sensing current for detecting a change in magnetoresistance flows in through one end of said series connection body, passes in turn through effective areas effective in changing magnetoresistance in each of said magnetoresistive effect element portions so as to penetrate said laminated surfaces, and flows out through the other end of said series connection body; and

wherein each of said switching elements switches on/off between said one end and said other end of said series connection body of said magnetoresistive effect element connected in parallel with said switching element, in accordance with a signal inputted into a control input portion of said switching element.

2. A memory device comprising:

a plurality of blocks arrayed;

wherein each of said blocks includes a plurality of memory cells connected electrically in series, and a plurality of switching elements connected in parallel with said memory cells in one-to-one correspondence;

wherein each of said memory cells is comprised of a magnetoresistive effect element having a plurality of magnetoresistive effect element portions;

wherein said magnetoresistive effect elements are laminated on one surface side of a substrate and disposed in a direction parallel to laminated surfaces of said magnetoresistive effect elements with respect to one another;

wherein said magnetoresistive effect element portions in each of said magnetoresistive effect elements are electrically connected in series so as to form an electric series connection body;

wherein opposite ends of said series connection body in each of said magnetoresistive effect elements are electrically connected to a sensing current supply portion so that a sensing current for detecting a change in magnetoresistance flows in through one end of said series connection body, passes in turn through effective areas effective in changing magnetoresistance in each of said magnetoresistive effect element portions so as to penetrate said laminated surfaces, and flows out through the other end of said series connection body; and

wherein each of said switching elements switches on/off between said one end and said other end of said series connection body of said magnetoresistive effect element connected in parallel with said switching element, in accordance with a signal inputted into a control input portion of said switching element.

3. A memory device according to Claim 2,

wherein said plurality of blocks are arrayed in a two-dimensional matrix extending in a row direction and in a column direction, while said plurality of memory cells in each of said blocks are arrayed in said column direction;

wherein said control input portions of said plurality of switching elements in said plurality of blocks are connected through a plurality of first read selection lines in respective rows so that each of said first read selection lines is shared among said control input portions in a row corresponding to said first read selection line;

wherein each of said blocks includes a selection switch connected to one of series connection ends of said plurality of memory cells in said block;

wherein the other ends of series connections of said plurality of memory cells in said plurality of blocks are connected through a plurality of read lines in respective columns so that each of said read lines is shared among said other ends in a column corresponding to said read line; and

wherein control input portions of said selection switches in said plurality of blocks are connected through a plurality of second read selection lines in respective columns so that each of said second read selection lines is shared among said control input portions in a column corresponding to said second read selection line.

4. A memory device according to Claim 1, wherein each of said switching elements is a field effect transistor.

5. A memory device according to Claim 1, wherein said magnetoresistive effect element portions in each of said magnetoresistive effect elements have one and the same layer structure.

6. A memory device according to Claim 1, wherein in each of said magnetoresistive effect elements a direction of said sensing current flowing through said effective area of one of paired magnetoresistive effect element portions selected from said plurality of magnetoresistive effect element portions and connected electrically with each other is opposite to a direction of said sensing current flowing through said effective area of the other of said paired magnetoresistive effect element portions.

7. A memory device according to Claim 1, wherein in each of said magnetoresistive effect elements, a pair of magnetoresistive effect element portions selected from said plurality of magnetoresistive effect element portions are connected electrically with each other by forming at least one of layers constituting one of said paired magnetoresistive effect element portions and a corresponding one of layers constituting the other of said paired magnetoresistive effect element portions integrally out of one and the same material.

8. A memory device according to Claim 1, wherein in each of said magnetoresistive effect elements, the number of said plurality of magnetoresistive effect element portions is even.

9. A memory device according to Claim 8, wherein in each of said magnetoresistive effect elements, said one end of said series connection body is a layer of one of said magnetoresistive effect element portions, which layer is on said substrate side; and

wherein in each of said magnetoresistive effect elements, said other end of said series connection body is a layer of another of said magnetoresistive effect element portions, which layer

is on said substrate side.

10. A memory device according to Claim 1, wherein in each of said magnetoresistive effect elements, each of said magnetoresistive effect element portions includes first and second magnetic layers.

11. A memory device according to Claim 10, wherein in each of said magnetoresistive effect elements, each of said magnetoresistive effect element portions includes a tunnel barrier layer put between said first and second magnetic layers.

12. A memory device according to Claim 10, wherein in each of said magnetoresistive effect elements, each of said magnetoresistive effect element portions includes a nonmagnetic metal layer put between said first and second magnetic layers.

13. A memory device according to Claim 10, wherein in each of said magnetoresistive effect elements, at least a pair of magnetoresistive effect element portions selected from said plurality of magnetoresistive effect element portions are connected electrically with each other by forming said first magnetic layer of one of said paired magnetoresistive effect element portions and said first magnetic layer of the other of said paired magnetoresistive effect element portions integrally out of one and the same material.

14. A memory device according to Claim 10, wherein in each of said magnetoresistive effect elements, at least a pair of magnetoresistive effect element portions selected from said plurality of magnetoresistive effect element portions are connected electrically with each other by forming said second magnetic layer of one of said paired magnetoresistive effect

element portions and said second magnetic layer of the other of said paired magnetoresistive effect element portions integrally out of one and the same material.

15. A memory device according to Claim 10, wherein in each of said magnetoresistive effect elements, said first magnetic layer of each of said magnetoresistive effect element portions is a free layer whose magnetization direction is variable in accordance with an external magnetic field, while said second magnetic layer of each of said magnetoresistive effect element portions is a pinned layer whose magnetization direction is fixed in a constant direction.

16. A memory device according to Claim 15, wherein in each of said magnetoresistive effect elements, magnetization directions of said second magnetic layers of said plurality of magnetoresistive effect element portions are identical.

17. A memory device according to Claim 15, wherein in each of said magnetoresistive effect elements, said first magnetic layer of each of said magnetoresistive effect element portions is disposed on the opposite side of said second magnetic layer to said substrate.

18. A memory device according to Claim 1, wherein two write lines are disposed for giving a magnetic field to each of said magnetoresistive effect elements so as to change over a magnetization state of said plurality of magnetoresistive effect element portions in said magnetoresistive effect element between a first state where all the resistance values of said plurality of magnetoresistive effect element portions become relatively large and a second state where all the resistance values of said plurality of magnetoresistive effect element

portions become relatively small; and

wherein said magnetization state of said plurality of magnetoresistive effect element portions in said magnetoresistive effect element is changed over in a lump by a combined magnetic field generated by said two write lines.

19. A memory device according to Claim 17, wherein two write lines are disposed for giving a magnetic field to each of said magnetoresistive effect elements so as to change over a magnetization state of said plurality of magnetoresistive effect element portions in said magnetoresistive effect element between a first state where all the resistance values of said plurality of magnetoresistive effect element portions become relatively large and a second state where all the resistance values of said plurality of magnetoresistive effect element portions become relatively small;

wherein said magnetization state of said plurality of magnetoresistive effect element portions in said magnetoresistive effect element is changed over in a lump by a combined magnetic field generated by said two write lines; and

wherein a magnetic circuit forming layer is provided in said magnetoresistive effect element for guiding said magnetic field generated by said two write lines into said free layers.

20. A memory device according to Claim 19, wherein said two write lines disposed for each of said magnetoresistive effect elements extend in different directions from each other and in parallel with said laminated surfaces so as to cross each other;

wherein said magnetic circuit forming layer provided for each of said magnetoresistive effect elements guides said combined magnetic field generated by said two write lines disposed for said magnetoresistive effect element, into said

free layers of said magnetoresistive effect element in the vicinities of four corners of a crossing portion of said two write lines.

21. A memory device according to Claim 18, wherein said two write lines disposed for each of said magnetoresistive effect elements are electrically insulated from each other.

22. A memory device according to Claim 18, wherein said two write lines disposed for each of said magnetoresistive effect elements are disposed on the opposite side of said magnetoresistive effect element to said substrate.

23. A magnetoresistive effect element comprising:

a plurality of magnetoresistive effect element portions laminated on one surface side of a substrate and disposed in a direction parallel to laminated surfaces of said magnetoresistive effect element portions with respect to one another;

wherein said magnetoresistive effect element portions are electrically connected in series so as to form an electric series connection body; and

wherein opposite ends of said series connection body are electrically connected to a sensing current supply portion so that a sensing current for detecting a change in magnetoresistance flows in through one end of said series connection body, passes in turn through effective areas effective in changing magnetoresistance in each of said magnetoresistive effect element portions so as to penetrate said laminated surfaces, and flows out through the other end of said series connection body.

24. A magnetoresistive effect element according to

Claim 23, wherein said magnetoresistive effect element portions have one and the same layer structure.

25. A magnetoresistive effect element according to Claim 23, wherein a direction of said sensing current flowing through said effective area of one of paired magnetoresistive effect element portions which are selected from said plurality of magnetoresistive effect element portions and which are connected electrically with each other is opposite to a direction of said sensing current flowing through said effective area of the other of said paired magnetoresistive effect element portions.

26. A magnetoresistive effect element according to Claim 23, wherein a pair of magnetoresistive effect element portions selected from said plurality of magnetoresistive effect element portions are connected electrically with each other by forming at least one of layers constituting one of said paired magnetoresistive effect element portions and a corresponding one of layers constituting the other of said paired magnetoresistive effect element portions integrally out of one and the same material.

27. A magnetoresistive effect element according to Claim 23, wherein the number of said plurality of magnetoresistive effect element portions is even.

28. A magnetoresistive effect element according to Claim 27, wherein said one end of said series connection body is a layer of one of said magnetoresistive effect element portions, which layer is on said substrate side; and

wherein said other end of said series connection body is a layer of another of said magnetoresistive effect element

portions, which layer is on said substrate side.

29. A magnetoresistive effect element according to Claim 23, wherein each of said magnetoresistive effect element portions includes first and second magnetic layers.

30. A magnetoresistive effect element according to Claim 29, wherein each of said magnetoresistive effect element portions includes a tunnel barrier layer put between said first and second magnetic layers.

31. A magnetoresistive effect element according to Claim 29, wherein each of said magnetoresistive effect element portions includes a non-magnetic metal layer put between said first and second magnetic layers.

32. A magnetoresistive effect element according to Claim 29, wherein at least a pair of magnetoresistive effect element portions selected from said plurality of magnetoresistive effect element portions are connected electrically with each other by forming said first magnetic layer of one of said paired magnetoresistive effect element portions and said first magnetic layer of the other of said paired magnetoresistive effect element portions integrally out of one and the same material.

33. A magnetoresistive effect element according to Claim 29, wherein at least a pair of magnetoresistive effect element portions selected from said plurality of magnetoresistive effect element portions are connected electrically with each other by forming said second magnetic layer of one of said paired magnetoresistive effect element portions and said second magnetic layer of the other of said

paired magnetoresistive effect element portions integrally out of one and the same material.

34. A magnetoresistive effect element according to Claim 29, wherein said first magnetic layer of each of said magnetoresistive effect element portions is a free layer whose magnetization direction is variable in accordance with an external magnetic field, while said second magnetic layer of each of said magnetoresistive effect element portions is a pinned layer whose magnetization direction is fixed in a constant direction.

35. A magnetoresistive effect element according to Claim 34, wherein magnetization directions of said second magnetic layers of said plurality of magnetoresistive effect element portions are identical.

36. A magnetoresistive effect element according to Claim 34, wherein said first magnetic layer in each of said magnetoresistive effect element portions is disposed on the opposite side of said second magnetic layer to said substrate.

37. A magnetoresistive effect element according to Claim 34, wherein said first magnetic layer of each of said magnetoresistive effect element portions is made from a soft magnetic material.

38. A memory device comprising a memory cell for storing data, said memory cell including a magnetoresistive effect element according to Claim 23.

39. A memory device according to Claim 38, further comprising one or more write lines for providing a magnetic field

for changing over a magnetization state of said plurality of magnetoresistive effect element portions in said magnetoresistive effect element between a first state where all the resistance values of said plurality of magnetoresistive effect element portions become relatively large and a second state where all the resistance values of said plurality of magnetoresistive effect element portions become relatively small.

40. A memory device according to Claim 39, wherein the number of said one or more write lines is two; and

wherein said magnetization state of said plurality of magnetoresistive effect element portions in said magnetoresistive effect element is changed over in a lump by a combined magnetic field generated by said two write lines.

41. A memory device comprising:

a memory cell for storing data, said memory cell including a magnetoresistive effect element according to Claim 36;

one or more write lines for providing a magnetic field for changing over a magnetization state of said plurality of magnetoresistive effect element portions in said magnetoresistive effect element between a first state where all the resistance values of said plurality of magnetoresistive effect element portions become relatively large and a second state where all the resistance values of said plurality of magnetoresistive effect element portions become relatively small; and

a magnetic circuit forming layer for guiding said magnetic field generated by said one or more write lines, into said free layers.

42. A memory device according to Claim 41, wherein the

number of said one or more write lines is two;

wherein said magnetization state of said plurality of magnetoresistive effect element portions in said magnetoresistive effect element is changed over in a lump by a combined magnetic field generated by said two write lines;

wherein said two write lines extend in different directions from each other and in parallel with said laminated surfaces so as to cross each other; and

wherein said magnetic circuit forming layer guides said combined magnetic field generated by said two write lines, into said free layers in the vicinities of four corners of a crossing portion of said two write lines.

43. A memory device according to Claim 39, wherein said one or more write lines are electrically insulated from one another.

44. A memory device according to Claim 39, wherein said one or more write lines are disposed on the opposite side of said magnetoresistive effect element to said substrate.